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ABSTRACT

The high percentage of high school pre-algebra students having difficulty learning the abstract concept of graphing ordered pairs on the Cartesian rectangular coordinate system was addressed by the creation and implementation of a computer-managed instructional program. Modules consisted of a pretest, instruction, two practice sessions, and a posttest. To increase motivation and thereby enhance learning, the practice modules were designed in the form of a game. Included are the purpose, research and solution strategy, method, results, and recommendations. Appended are sample tests, student data, user and programming documentation, and flowcharts. (Author/KR)

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A COMPUTER PROGRAM TO INCREASE COMPREHENSION OF THE CARTESIAN RECTANGULAR COORDINATE SYSTEM IN HIGH SCHOOL PRE-ALGEBRA STUDENTS

by

I. Sheck Exley

A Practicum Report
submitted to the faculty of the Center for the Advancement of Education of Nova University in partial fulfillment of the requirements for the degree of Master of Science.

The abstract of this report may be placed in a national database system for reference

August/1989

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AUTHORSHIP STATEMENT

I hereby testify that this paper and the work it reports are entirely my own. When it has been necessary to draw from the work of others, published or unpublished, I have acknowledged such work in accordance with accepted scholarly and editorial practice. I give this testimony freely, out of respect for the scholarship of other workers in the field and in the hope that my own work, presented here, will earn similar respect.

Signed: I. Sheck Exley

I. Sheck Exley, Jr.

ABSTRACT

A Computer Program to Increase Comprehension of the Cartesian Rectangular Coordinate System in High School Pre-Algebra Students.
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The high percentage of high school Pre-Algebra students having difficulty learning the abstract concept of graphing ordered pairs on the Cartesian rectangular coordinate system was addressed by the creation and implmentation of a computer-managed instruction program. Modules included a pretest, instruction, two practice sessions, and a posttest. To increase motivation and thereby enhance learning, the practice modules were designed in the form of a game. Students were exposed to the program on computers over a period of two weeks. The results indicated a greater increase in achievement for the target group than for four similar Pre-Algebra classes of this researcher. Students within the targeted group demonstrated a greater increase in attitudes toward plotting coordinates as well. It was concluded that the computer-managed instruction program designed by this researcher can be a valuable tool to facilitate and increase comprehension of plotting coordinates. Appendices include sample tests, student data, user and programming documentation, flowcharts, and the complete program listing.

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Observer Verification Form

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Dear Observer:

Practicum students in Nova's M.S. and Ed.S. programs are asked to provide external verification that the project activities reported in their final practicum documents took place as described. You have been designated an observer to fulfill this confirmation function by the student named below. On this sheet, then, please write a note attesting to your knowledge of the project activity described in the final practicum report to which this will be attached. (Note that you are not asked to evaluate or make judgments about the quality of the project.)

Practicum Title: A computer Program to Increase Comprehension of the Cartesian Rectangular Coordinate System in High School Pre-Algebra Students

Student's Name: Irby Sheck Exley, Jr.

Program Site: Suwannee High School Date: June 1, 1989

Observer's Name: Marion L Harvard Principal Suwannee
(please print---------and sign)

Observer's position: Asst Principal Phone #: 904-362-2382 ext 205

Observer's comment on impact of the project (handwritten):

Students were very involved in using the computer program and were having fun while learning. M Harvard

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CHAPTER I

PURPOSE

Background

The problem described herein existed at a medium-sized high school in a rural community in north central Florida. The school drew students for grades 9-12 from most of the surrounding county, an area of more than 400 square miles. Many of these students were bused more than 20 miles one-way to and from school. A single middle school for grades 6-8 prepared most of the students for the high school. The small balance of students attending the high school were transferred from other schools. Total enrollment at the school was 1265 students. Two hundred eighty-four of that total were Black, 935 were white and the remaining nine were of different ethnic groups. Five hundred seventy-five of the students were female and 653 were male.

The community in which the high school resided had a population of 7603. It furnished goods and services to the surrounding agricultural community, which grew chiefly tobacco, beef, pulpwood, poultry, grain and watermelons. There were no institutions of higher

learning (junior college or higher) in the community. Few of the entertainment and sports options available in larger cities existed there. No professional sports teams or movie theaters were in the community, for example. One positive aspect of this paucity of distractions was that the high school was a major focus of the community. More than half of the news items in the local biweekly newspaper dealt with the school system and school-related activities. This emphasis developed a tradition of excellence in academics (state brain bowl champions three of the past four years), music (highest possible rating for the school band in state competition this year), art (more winners in state competition each of the past two years than any other school of similar size), and athletics (state football champions each of the past two years). Also due to this community focus as well as the rural setting was the fact that drug- and violence-related incidents at the school were probably less prevalent than at many other schools in the state.

While the building in which the practicum was implemented was twenty-one years old, the 30 foot by 24 foot classroom was neat, clean, and comfortable. Central heating and air conditioning generally maintain

a temperature of 70-78 degrees Fahrenheit all year. There were 32 student desks of uniform color, adequate lighting from 20 fluorescent lamps arranged in two rows along the ceiling, and one large chalkboard at the front of the class and a smaller one at the rear. The chalkboard at the front was flanked by bulletin boards containing cartoons, articles, and news about students. A large motivational quote was posted across the top of the front chalkboard, and changed on a weekly basis. The rear board was used to list the names of A students and give the homework assignments. The teacher's desk and two file cabinets were at the rear of the classroom. All instructional activity took place at the front of the classroom. Explanations were made using chalkboard examples, and individual assistance was rendered by the teacher during practice sessions. Games and humor were frequently used to maintain student interest. The text used to teach the Pre-Algebra course was Holt Pre-Algebra (1980) by Eugene D. Nichols, et. al.

The computer lab used in implementing the proposed solution to the problem addressed by the writer was located in the same building. It contained 16 Tandy 1000 HX computers with monochrome monitors and two

Tandy 1000 TX computers with color monitors. Four units were located on each of four large tables so that students could not see what other students were doing unless they completely turned around or stood up and walked around the table. The two color units were located on a long table adjacent to the teacher's desk. Behind this long table was the board used to explain computer operations, applications, programming, etc. The room was identical in size to the Pre-Algebra classroom, with similar lighting, cleanliness and climate control. Neither room had any exterior windows.

Target Population

The target population affected by the problem that this practicum dealt with was a group of 23 Pre-Algebra students in fifth period class at the high school. Sixteen of the students were in the ninth grade, six were in the tenth grade and there was one eleventh grader. This makeup was typical of the five Pre-Algebra classes taught at the school. Four of the fifth period students were Black, and there was also one Puerto Rican-American student. The balance of the students were white. Eleven of the 23 students were female.

Criteria for enrollment in Pre-Algebra at the high school included a minimum score of 50 on the California Achievement Test (CAT), a minimum C average in General Math I, and a minimum score of 13 correct on a 30-item Algebra diagnostic test designed by the math department at the high school. Occasionally parents of students failing to meet these criteria would sign waivers to have their children enrolled in Pre-Algebra rather than General Math II, the option for slower ninth graders, or General Math III, the option for slower tenth and eleventh graders. Brighter ninth graders were enrolled in Algebra I, and tenth and eleventh graders that do well in math were also in that course or even higher level courses. Students considering attending college were encouraged to enroll in Pre-Algebra and higher level courses, but generally had to meet the criteria unless parental waivers were furnished. Occasionally the guidance department of the school would also enroll students in Pre-Algebra who did not meet the criteria, but such exceptions were rare. A total of 129 students were presently enrolled in the five Pre-Algebra classes taught at the high school.

The target population arrived at the first class

of the day at 8:10 AM. Since the vast majority of ninth graders were bused to the school, most of the students had already been up for nearly two hours or more. They attended seven 50-minute classes during the day, usually including one study hall and one physical education class. Fifth period class usually lasted from 11:55 AM to 12:45 PM. Lunch for all fifth period students was normally from 12:45 PM to 1:20 PM. To facilitate access to the computer lab for the purpose of this study, however, this schedule was altered so that fifth period students would go to lunch from 11:50 AM to 12:25 PM, and would attend Pre-Algebra class from 12:35 PM to 1:20 PM. The last class of the day ended at 3:10 PM, but many bused students did not arrive home until after 4:00 PM. Often they were expected to help with agricultural chores thereafter, which may have limited the amount of time that was applied to homework assignments.

Writer's Role and Responsibilities

The writer had taught five or six classes of Pre-Algebra for each of the past four years. This year the writer also taught a semester class entitled "First Aid and Safety", which included American Red Cross certified training in first aid, cardiopulmonary

resuscitation (CPR) and water safety (advanced lifesaving). In addition to these six classes the teacher had various additional duties such as lunch room duty, and also coached two sports and sponsored one club.

In the classroom the writer's responsibility was to teach the students as much as possible about math in general, and Pre-Algebra in particular. Special attention was given to the 54 state-mandated objectives for the course. To achieve these objectives, interest was maintained through dynamic presentations and liberal use of math games and activities. Student stress that was counterproductive to learning was reduced through the maintenance of a warm, friendly atmosphere and the frequent use of humor. This atmosphere, combined with recognition and meaningful reinforcement for improvement and high achievement, also helped the students to develop a more positive self-image.

Identification of the Problem

Students were enrolled in Pre-Algebra at this high school because their classroom grades and scores on the California Achievement Test (CAT) were not sufficiently high to qualify them for Algebra I. The minimum

requirement for enrollment in Pre-Algebra was a C average in General Math, a 50 on the CAT, and a score of 13 correct on a 30-item algebra diagnostic test designed by the math department at the high school. The scores required for Algebra I, however, were a B average in General Math, a 65 on the CAT, and an 18 on the algebra diagnostic test. For this reason Pre-Algebra students, while more successful in learning mathematics than their fellows enrolled in General Math and remedial courses, were considered slower than their peers in Algebra I. It had been observed that these students may have difficulty comprehending operations involving the substitution of variables for numbers without lengthy demonstration and explanation involving concrete reasoning rather than abstract thought. The students might also become discouraged due to their lack of rapid success and might develop a dislike for mathematics in general, which further retarded their learning process.

The difficulty in understanding operations involving the substitution of variables for numbers may have involved a delay in stage transition of cognitive development. Jean Piaget's theory of cognitive development described a series of four developmental

stages through which children progressed with age. The third of these stages, concrete operations, usually lasts from age 7 to 11 or 12 years. During this stage, thought processes are directed to real events observed by the child. The abstract or hypothetical reasoning required for algebra cannot occur until the onset of the fourth and final stage, called formal operations. This stage occurs from age 11 or 12 to 14 or 15 years. Most Pre-Algebra students were 14 years of age when the course begins. If the student had not arrived at the formal operations stage, instruction in algebraic concepts would not be successful because the student was not yet developmentally at the stage to comprehend them.

There was strong evidence that the frustration caused by a failure to comprehend abstract math concepts had led to considerable discouragement on the part of the students. This frustration manifested itself in a variety of ways. Students looked for reasons not to stay on task during drill and practice sessions, refusing to work or answering questions with the pat excuse, "I don't understand." Another commonly observed behavior was a complaint such as, "I'll never have to use this in real life," or "this is boring."

The students making these statements usually were the students who performed least well on tests and quizzes. Some students actually developed an intense dislike for mathematics in general. For example, some Pre-Algebra students, when given extra time at the end of the period to work on math homework, had been observed to choose to surreptitiously work on other subjects instead. This was in spite of the fact that they were penalized for this behavior when they were invariably caught. Furthermore, frequently these assignments from other classes were not due until the next day.

The problem of improving the comprehension of algebraic concepts by undermotivated Pre-Algebra students became more pronounced as the course of study progressed and the material became more abstract. The sixteenth and final chapter of the textbook used for the course coverd graphing and addressed for the first time five of the 54 objectives mandated by the state of Florida for the Pre-Algebra course. These objectives included:

5. Demonstrate the ability to graph simple linear equations and inequalities.
   The student will
   5.01 identify the axes and quadrants of a Cartesian rectangular coordinate system
   5.02 graph a set of ordered pairs in a Cartesian rectangular coordinate

system
5.03 identify a set of ordered pairs given a set of first components and a rule for obtaining corresponding second components
5.04 graph a linear equation in two variables in a Cartesian rectangular coordinate system
5.05 graph an inequality on a number line

Successful completion of these objectives required that the student be able to grasp the abstract replacement of a number by a variable such as x or y and by an assigned location on a number line or Cartesian rectangular coordinate system. Scores by fourth and fifth period students on chapter tests in school year 1987-1988 revealed that the students performed much lower on the relatively abstract chapter 16 material than on the chapter 1 material, which was largely concrete operations. This data, summarized in Table 1, suggested that the chapter 16 material was more difficult for the students to learn. The mean of the grades for the test on the chapter 16 material was 84.2, where the mean of the test grades for chapter 1 was 91.6, 7.4 points higher.

This project attempted to solve the problem of undermotivated high school students who were having difficulty learning the abstract concept of graphing ordered pairs on the rectangular coordinate system.

TABLE 1

A Comparison of Individual Pre-Algebra Students' Scores on Chapter Tests in 1987-1988

Student #	Chapter 1	Chapter 16	Difference
1	94	94	0
2	91	77	14
3	88	97	-9
4	94	88	6
5	88	94	-6
6	97	56	41
7	82	88	-6
8	88	55	33
9	94	94	0
10	94	94	0
11	100	63	37
12	94	85	9
13	85	91	-6
14	88	97	-9
15	97	100	-3
16	91	37	54
17	82	79	3
18	91	67	24
19	100	76	24
20	97	85	12
21	91	94	-3
22	88	73	15
23	97	100	-3
24	97	82	15
25	88	85	3
26	82	82	0
27	94	100	-6
28	82	79	3
29	97	43	54
30	94	64	30
31	100	94	6
32	94	97	-3
33	91	85	6
34	91	82	9
35	97	94	3
36	73	82	-9
37	97	85	12
38	100	97	3
39	97	85	12
40	88	85	3
41	79	91	-12
42	100	76	24
43	82	91	-9
44	85	84	1
45	88	97	-9
46	91	79	12
47	100	70	30
48	100	100	0
49	97	100	-3
50	88	91	-3
51	97	100	-3
52	85	100	-15
53	88	67	21
54	91	88	3
55	94	91	3
MEAN	91.6	84.2	7.4

Outcome Objectives

The implementation of the solution to the problem was to take place over a period of two weeks. By the end of this time, the 23 fifth period students targeted in this practicum were to have improved their comprehension of plotting points on the Cartesian rectangular coordinate plane by a significant amount. This improvement was to be measured in comparison to their pretest scores as well as in comparison to the achievement of all other Pre-Algebra students attending the school. Additionally, the writer expected marked improvement in the students' attitudes toward graphing on the coordinate plane. The specific outcome objectives expected were:

1. After two weeks of computer-managed instruction, the 23 high school Pre-Algebra students participating in the Astrogator Graphing Program would have increased their skills by 10 percent, as measured by the mean of their scores on the Coordinate Plotting Mastery Test designed by the author (see Appendix A).
2. After two weeks of computer-managed instruction, the 23 high school Pre-Algebra

students participating in the Astrogator Graphing Program would have increased their skills by 10 percent more than all other Pre-Algebra students enrolled at the school, as measured by the mean of their scores on the Coordinate Plotting Mastery Test.

3. After two weeks of computer-managed instruction, the 23 high school Pre-Algebra students participating in the Astrogator Graphing Program would have improved their attitudes toward graphing coordinates by five percent more than all other Pre-Algebra students enrolled at the school, as measured by the mean of their scores on the Survey of Attitudes Toward Pre-Algebra designed by the author (see Appendix B).

CHAPTER II

RESEARCH AND SOLUTION STRATEGY

Research revealed several different alternatives to solving the problem of helping undermotivated Pre-Algebra students learn the abstract concepts of graphing points on the Cartesian rectangular coordinate plane. The text used in the course suggested leading into the plane by starting with a review of the number line (Nichols et. al, 1980). Plotting points in the first quadrant would be introduced by the use of the analogy of streets and avenues where x was the street and y was the avenue. This traditional approach had been used by this writer in the past with minor variations such as the seats in a theater analogy.

Meneeley (1980) recommended the supplemental use of two sets of activity worksheets. Ths first set would list points and letters on a plane and would ask the student to respond with the correct ordered pair for the point. The second set was simply a blank plane, upon which the student was asked to plot a series of ordered pairs. Variations of this supplemental strategy had also been used by the writer, with varying

degrees of success.

Kroll (1985) had designed an interesting series of activities that developed the idea of the coordinate plane itself in gradual steps. The student would begin with an activity involving the filling of cells of a chart, then progress to the introduction of the coordinate grid in the familiar context of a map. Next would come an activity using grids of letters in the first quadrant, which would initiate the idea of ordered pairs. Finally, there was an exercise where the student would connect dots found by plotting ordered pairs to form a picture.

The National Council of Teachers of Mathematics (1984) had pointed to the inadequacy of the aforementioned approaches: "Much of the instructional time currently devoted to acquiring proficiency with paper-and-pencil algorithms should be reallocated to support a range of new topics..." There was no denying that students find the construction of coordinate planes tedious, even when most of the work was done for them with a worksheet as in the Kroll study. Nor could one argue that drawing the plane enhances learning when the student generally would have no trouble constructing the plane after the first attempt. By

having the students complete their assignments on a computer instead, Bridges (1985) reported finding that students would end up doing three times as many problems as she could encourage them to do with pencil and paper. She added, "...computers help students create a positive self-image, [and] also help develop a sense of appreciation toward mathematics as a subject." Perhaps Johnson (1988) addressed the role of the computer in teaching mathematics most succinctly: "No secondary mathematics classroom should be without immediate access to a microcomputer and a graphing package."

An additional advantage of using a computer-based approach to the solution of the problem addressed by this practicum was given by Ediger (1988). He related the use of a well-designed computer instructional program to B. F. Skinner's classic concept of programmed learning, where pupils would achieve and progress in small steps. Feedback and reinforcement was prompt, and each response given by the student was measureable and observable. This was borne out by a study where children that had been exposed to math lessons involving LOGO computer programs showed significant improvement in ability and attitude

(Clarke, 1985).

In addition to the Clarke study, there were numerous examples of successful utilization of computer-assisted instruction (CAI) in the mathematics classroom. Walton (1986) reported that the use of computer programs to teach probability was engaging and motivating to the student. Bratton (1988) had used a computer spreadsheet to assist in learning synthetic division. LOGO construction of spirolaterals, repeating geometric patterns, using dot paper and a computer, was found by students in grades 6-12 to be a "fascinating topic" in a study by Billstein (1987). LOGO had also been used with computer graphing to help students determine the largest open-top box that can be created from a piece of paper (Thomas et. al., 1988). Still another example of success with computers in the mathematics classroom was Johnson's procedure of using computers for investigating the number pi and number crunching (1987). Students were found to have a better understanding and were encouraged to explore additional material.

Many CAI programs involved the use of the Cartesian rectangular coordinate plane, which was central to the problem focused upon by this practicum.

Lott and Crued (1989) used the plane and LOGO to help students study transformation geometry analytically. Zehavi (1988) developed software called "MixMax" where arithmetic tasks were presented graphically on the coordinate plane to raise interest and curiosity. Another article discussed plotting coordinates on the plane to solve real-life problems by finding the line of best fit through the use of a computer (Haigh, 1987). Koslov (1984) successfully used computer-assisted practice in graphing sine and cosine functions in the classroom. Recently Johnson (1988) compared no fewer than 23 programs that were commercially available to plot the graphs of functions on the coordinate plane on a computer monitor. While this software does an excellent job of plotting graphs, it was intended as a learning accessory only since there was no interactive activity on the part of the student to design the graphs. Meyer (1988) went to the other extreme, however, where not only did students interact with the computer, but also wrote the programs designing the graphs themselves. The graphs would then be used to control the movements of a theoretical robot. Despite this multitude of computer programs for the classroom, the writer was unable to locate any interactive CAI

that specifically addressed the development of the concept of plotting points on the coordinate plane.

Almost as rare were computer programs using games to help motivate students to do math activities involving the coordinate plane. One of the few examples was "Spies in a Computer", a program written by Robert D. Sweetland (1984), which used a game to find the location of a spy on the plane by guessing coordinates. Reinforcement from the computer gave the distance to the spy to aid in the formulation of the next guess. While this was much too advanced for Pre-Algebra students, it was similar in some respects to the solution that this writer posed to this practicum problem. It was also encouraging to note that Sweetland described the game as "highly motivating" and "effective in the classroom."

"Green Globs" was an instructional program designed as a game that called for the computer to scatter 13 green spots across a coordinate plane (Dugdale, 1981). The student would then be required to type in equations whose graphs would explode all of the green globs. Diagnostic feedback was provided to correct the ideas used. The activity was found to be meaningful and highly motivating to the students. In a

later report (Dugdale and Kibbey, 1983), it was mentioned that the activity was found to be "appropriate for students of widely varying backgounds and abilities." Unfortunately, this scope did not include the students targeted by this practicum, who were just starting to learn about the coordinate plane.

Based upon the success of game-oriented CAI programs like "Green Globs" and "Spies in the Computer," as well as the resounding success of computer-assisted instruction in all areas of the mathematics classroom, the writer decided to design an original computer-managed instruction program to solve the problem of undermotivated Pre-Algebra students having difficulty learning to plot points on the coordinate plane. This strategy included a motivational game for drill and practice, and this motivation would be enhanced by the listing of the highest-scoring students during the activity, a practice found valuable in the "Green Globs" study.

CHAPTER III

METHOD

Resources

The utilization of resources during the implementation of this practicum was substantial, but it was designed so that it did not disrupt or interfere with other school activities. This was necessary to secure permission to implement the practicum as well as encourage the assistance and cooperation of supervisors and colleagues.

People

The writer was able to implement the practicum without any additional classroom assistance, and without negatively impacting on the writer's other duties. The practicum was implemented during the two weeks that would normally be allocated to instruct students in plotting coordinates on the Cartesian rectangular coordinate system and related skills. For activity verification, an assistant principal made brief, informal appearances to observe the implementation.

Materials

A number of materials were designed for the project. First, 40 reusable copies of the Coordinate Plotting Mastery Test (see Appendix A) were mimeographed and stapled as pretest/posttest booklets for the Pre-Algebra students not in the target group. Similarly, 300 copies of the Survey of Attitudes Toward Pre-Algebra (see Appendix B) were run off so that they could be administered to all Pre-Algebra students before and after the implementation. Finally, 50 copies of appropriate portions of the User Documentation (see Appendix G) were made available to the target group. The extra copies of the documentation proved invaluable since many of the students lost their original handouts during the project. To provide additional motivation for the two practice sessions, copies of the names of the 10 highest scoring students and their respective scores were given to each of the 23 students in the target group on the following days. The chalkboard was also used sparingly to expand upon explanations given during the first day's orientation.

Time

Two weeks (10 days) were used to implement the practicum. Students in the target group were asked to

change lunches so that they could use the computer lab without interfering with normally scheduled computer classes. Of course, a substantial amount of additional time was invested by the writer. Approximately 200 hours were spent in writing the computer program and another 10 hours spent in establishing detailed lesson plans and preparing printed aids and evaluations. At the end of the implementation, 15 more hours were spent compiling and evaluating the results.

Space

No special space had to be allocated for the practicum. The instructor's normal classroom was used for the first 15 minutes of each class involving the targeted students, as well as all of each of the other four Pre-Algebra classes. The remainder of the targeted group's period of instruction was spent in the normally unoccupied computer lab. Movement of the targeted students between the classrooms was not a disruptive influence on other classes in the building because the same five minutes was used for students in those classes to proceed to the lunchroom.

Equipment

Located in the computer lab were 16 Tandy 1000 HX computers with monochrome monitors and two Tandy 1000

TX machines with color monitors. During the implementation of the practicum it was discovered that two of the computers did not have sufficient graphics capability to run the programs, so only 16 of the machines were actually used by the targeted students. A wall-mounted chalkboard was utilized for expanding upon the directions given in the user's documentation.

Monitoring

Detailed written records of progress were maintained by the writer on a daily basis throughout the two week implementation. A complete description of work accomplished and time spent on each task was included, as well as records of individual student's scores, progress, attitudes, and comments. In addition to the instruments used in the evaluation of the practicum, the writer was able to use these records to determine the degree to which the lesson plans and time line established for the two weeks implementation were realistic and appropriate. The daily monitoring on a per student basis also allowed mid-course corrections, which were necessary for several targeted students who missed class.

Evaluation

Written instruments used to evaluate the success of the practicum included the Coordinate Plotting Mastery Test (see Appendix A), administered as a pretest on the second day of the implementation as well as a posttest on the eighth day, and the Survey of Attitudes Toward Pre-Algebra (see Appendix B), administered on the second and ninth days.

The Coordinate Plotting Mastery Test was given to the targeted students on the computer and results were saved to files included as part of the computer program. All other Pre-Algebra students took the instrument as a written examination. For increased statistical accuracy, 20 items, instead of the usual 15, were included on the test, which was also designed as a multiple choice instrument to make grading easier. The subject matter also permitted the design of four appropriate distractors for each item instead of the normal three, which reduced the possibility of students improving their scores through guessing.

The Survey of Attitudes Toward Pre-Algebra was administered to all Pre-Algebra students, including the targeted group, as a written instrument. The 10 items were simple comparisons of many of the subjects covered

in Pre-Algebra during the year and graphing coordinates, the subject addressed by this practicum. After being instructed that this instrument would have no effect on their grades, the students were asked to indicate which of the alternatives they preferred in each of the 10 pairs of subjects.

Percentage scores were computed for both of the aforementioned instruments, and at the conclusion of the implementation the pretest score was subtracted from the posttest results to establish the amount of gain or loss in the scores. An additional and less formal evaluation used for the practicum was the record of progress maintained on a daily basis during the implementation, which included numerous notes on actions and verbal statements made by the students. These behaviors were valuable indicators of students' attitudes toward the subject addressed by the practicum.

CHAPTER IV

RESULTS

For grading purposes, the posttest scores of all Pre-Algebra students were recorded immediately following the completion of the implementation of the practicum. It was noted that the scores for the targeted group were quite high, but the scores for the other students were also impressive. Students' comments following the implementation, and a quick scan of the scores on the Survey of Attitudes Toward Pre-Algebra (see Appendix B) suggested marked improvement in students' attitudes as well for both groups. The writer's schedule did not permit formal tabulation and comparison of the data until several days later. During this period, frankly, quite a few moments were spent wondering whether the difference in improvement shown by the two groups would be sufficient to match some of the fairly high criteria established to ascertain the success of the practicum. For example, the mean of the scores of the targeted students on the posttest were predicted to be 10 percent higher than all other Pre-Algebra students. With hindsight, the writer thought that a five percent difference would have been

sufficiently significant on the 20-item instrument (see Appendix A). Despite these worries, the results were surprisingly dramatic.

The pretest and posttest results for the targeted students are summarized in Appendix C. The mean of the pretest scores was only 40.3 percent. The mode and the median were 40 percent, and the scores ranged from 25 percent to 55 percent. The writer had predicted a 10 percent improvement on the mean of the scores on the posttest to indicate the success of the practicum. The degree of improvement was nothing less than astounding. The mean of the posttest scores zoomed up to 88.4 percent, an improvement of 48.1 percent and more than doubling the original scores, despite the fact that no prior indication was given to any student that the posttest would be similar to, much less identical to, the pretest. Since more than half of the targeted students achieved perfect scores, the median and mode both jumped to 100 percent. These results would have been even more shocking had the posttest score of student number 11, who experienced behavioral difficulties on the day of testing, been eliminated. Incidentally, the sample includes only 16 of the 23 originally targeted students because seven of the

students missed too many classes to be exposed to the proper sequence of the implementation (ie., pretest, instruction, drill and practice, and posttest).

The second criterion for success of the practicum predicted that the mean of the improvement of the targeted students on the posttest would exceed the mean of the improvement of all other Pre-Algebra students by 10 percent, a standard that the writer belatedly believed to be excessively high. While all other students did experience considerable improvement in their skills (see Appendix D), the mean of this improvement was 35.4 percent, a full 12.7 percent less than the targeted group. Therefore, this criterion was also exceeded by the results of the practicum. It is interesting to note that, while 56.3 percent of the targeted group achieved perfect scores on the posttest, only 16.3 percent of the other students attained that level.

The final criterion to evaluate the success of the practicum was that the targeted group's attitudes would improve after the two weeks of instruction by five percent more than all other Pre-Algebra students. The instrument used was the Survey of Attitudes Toward Pre-

Algebra designed by this writer (see Appendix B), which was administered both at the beginning and at the conclusion of the practicum. Survey results for the targeted students and all other Pre-Algebra students are summarized in Appendices E and F, respectively. The mean of the targeted students' scores, based on the responses favoring graphing coordinates as a percentage of total responses, improved substantially, from 37.5 percent before computer-managed instruction, to 83.1 percent afterwards. While similarly-measured attitudes of all other Pre-Algebra students also improved, the 45.6 percent improvement attained by the targeted group nearly doubled the 24.5 percent increase shown by the others. So the final criterion of five percent was quadrupled by the 21.1 percent difference achieved during the practicum.

The dramatic improvement in attitude shown by the targeted group was strongly supported by the writer's recorded observations of their actions and statements. On only the second day using the computers, a student usually showing little interest in class demanded, "Give me my disk so I can start now!" This dramatic reversal in attitude was all the more surprising since this transpired four minutes before the tardy bell to

start class, a time when the students normally prefer to talk to their friends in the hall, etc. The rest of the class quickly followed suit. This is the first time that this writer has ever seen any students prefer to do math classwork over free time to visit with other students. This behavior was generally duplicated on each succeeding day that the targeted group was in the computer lab. Upon completion of the instruction module, surely the least interesting part of the program, several students asked permission to repeat the module. Most of the students were anxious to go on to the next module. The drill and practice modules, designed as games, were even more motivating. At the conclusion of this period, the writer was once more shocked to see a behavior never before witnessed in school: several students were so interested in the computer-managed drill that they refused to leave the computers. This amazing behavior was repeated on subsequent days, despite the fact that the writer refused to excuse their tardiness to their next class.

The behavior of the other students was also interesting. By the second day of the implementation, the other students were complaining that "it's not fair that the other [targeted] students get to use the

computers!" This was even before the targeted group had the opportunity to take the highly motivating drill and practice modules.

On the basis of the considerable degree to which all three criteria were exceeded, plus the significant additional observations of the results of the evaluation instruments administered and students' comments and other behavior, it must be concluded that this practicum was a resounding success.

CHAPTER V

RECOMMENDATIONS

This practicum has demonstrated clearly the dramatic improvement in students' skills and attitudes toward learning that can be achieved when the students are exposed to a computer-managed instruction program, especially when drill and practice is designed as a game. The writer can offer strong support to Johnson's (1988) statement, "No secondary mathematics classroom should be without immediate access to a microcomputer..." Unfortunately, while the high school where this practicum was implemented excels in many regards, no mathematics classroom at the school presently includes a computer. The writer plans to disseminate this practicum to the Assistant Principal in charge of curriculum and other interested persons at the school with the fervent hope that this situation will change in the near future.

The remarkable success of this practicum has also led to the belief that computer-managed instruction will be successful in teaching other aspects of mathematics. For example, one long-term personal goal is to have a substantial number of computers available

in the writer's classroom, along with high quality commercial software where available. These programs would be supplemented by original programs generated by the writer.

Meanwhile, the writer will distribute a copy of the program to all interested teachers of mathematics. Educators who do not come into contact with this writer may learn of it in several ways. First, the writer will allow ERIC to make this document available on microfiche or in paper copy. A condensed version including the basic drill and practice module program and results of the practicum will be submitted for publication to various publishers of respected professional journals, such as the National Council of Teachers of Mathematics, the International Council of Computer Education, and the Association for Computing in Mathematics and Science Teaching.

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APPENDIX

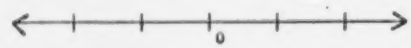
Appendix A

Coordinate Plotting Mastery Test

This test will be given to all Pre-Algebra students at the school as a pretest and a posttest.

Appendix A

Coordinate Plotting Mastery Test



1. To the right of zero are all of what kind of numbers?

A. positive numbers

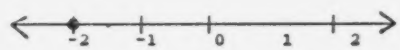
B. negative numbers

C. imaginary numbers

D. even numbers

E. odd numbers

TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]



2. The dot is located at:

A. -2

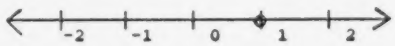
B. -1

C. 0

D. 1

E. 2

TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]



3. The dot is located at:

A. -2

B. -1

C. 0

D. 1

E. 2

TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

4. The vertical line is called:

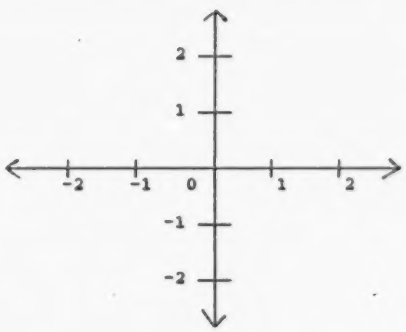
A. a

B. b

C. c

D. x

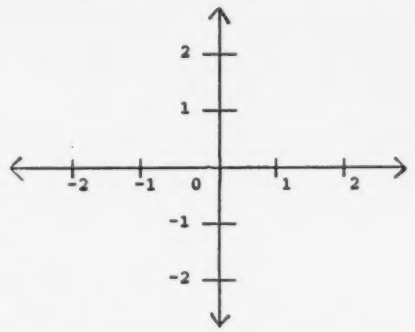
E. y



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

5. The horizontal line is called:

A. a
B. b
C. c
D. x
E. y



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

6. (2,3) is called a(an):

A. force couple
B. ordered pair
C. infinite set
D. product
E. quotient

TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

7. In (-3,4), the first number gives which coordinate?

A. a

B. b

C. x

D. y

E. z

TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

8. Where the lines meet is called the:

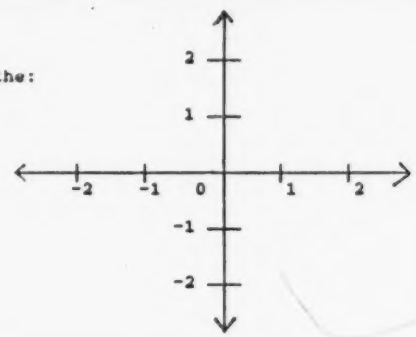
A. radial

B. radian

C. radical

D. nexus

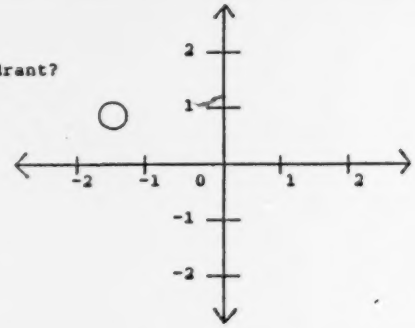
E. origin



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

9. The dot is located in which quadrant?

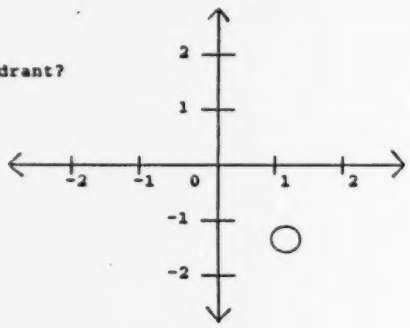
A. I
B. II
C. III
D. IV
E. V



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

10. The dot is located in which quadrant?

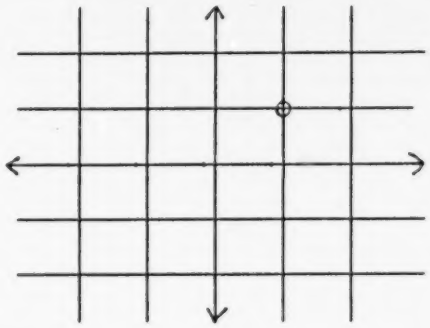
A. I
B. II
C. III
D. IV
E. V



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

11. The dot is located at:

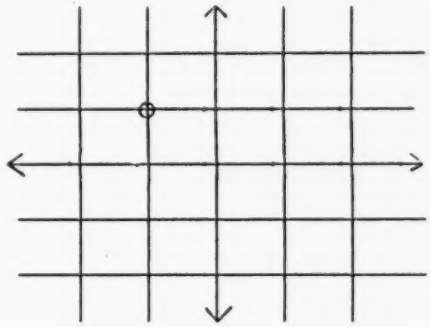
A. (-1,1)
B. (1,-1)
C. (-1,-1)
D. (1,1)
E. (-2,-2)



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

12. The dot is located at:

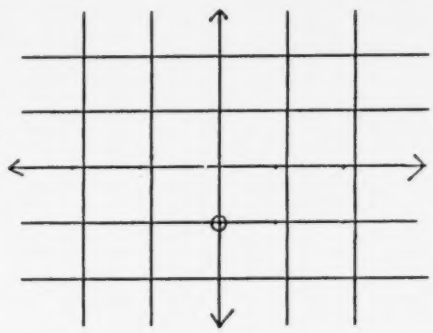
A. (-1,1)
B. (-1,-1)
C. (1,1)
D. (1,-1)
E. (3,-2)



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

13. The dot is located at:

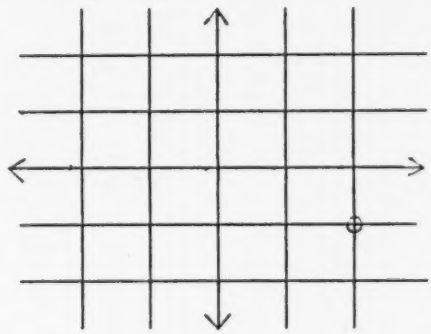
A. (1,0)
B. (0,1)
C. (-1,0)
D. (0,-1)
E. (-2,0)



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

14. The dot is located at:

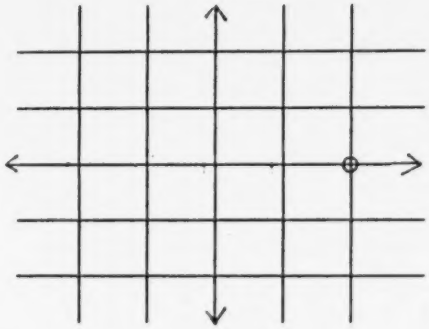
A. (-2,2)
B. (-2,1)
C. (1,-2)
D. (-1,2)
E. (2,-1)



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

15. The dot is located at:

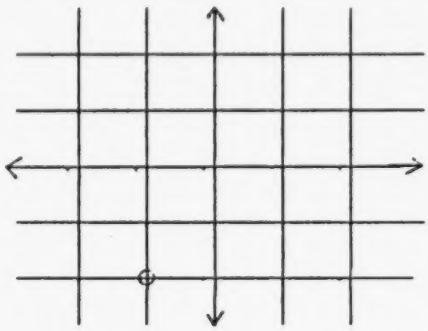
A. (0,-2)
B. (-2,0)
C. (0,2)
D. (2,0)
E. (1,-2)



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

16. The dot is located at:

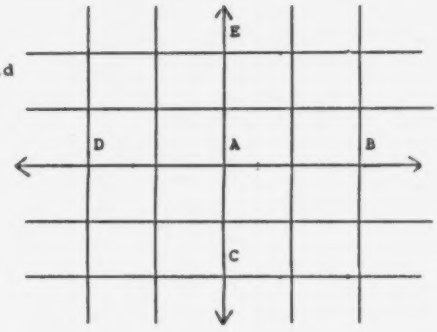
A. (-2,1)
B. (-1,-2)
C. (-2,-1)
D. (-1,2)
E. (2,-1)



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

17. A graph of the point (0,2) would place a dot at which point?

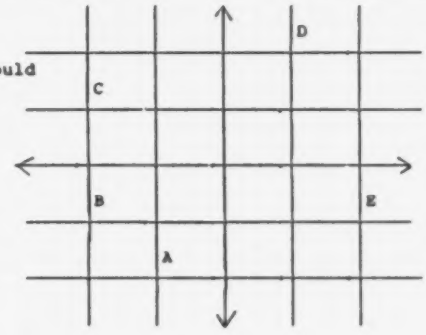
A. A
B. B
C. C
D. D
E. E



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

18. A graph of the point (-2,-1) would place a dot at which point?

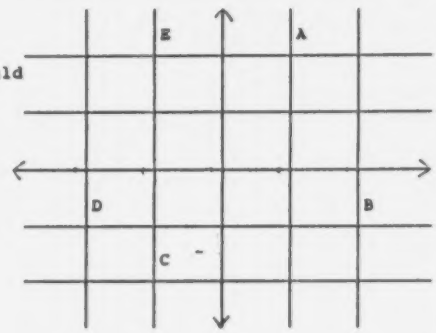
A. A
B. B
C. C
D. D
E. E



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

19. A graph of the point (-1,2) would place a dot at which point?

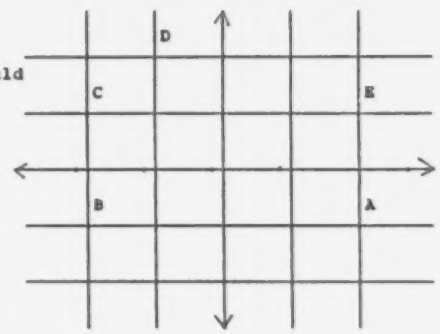
A. A
B. B
C. C
D. D
E. E



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

20. A graph of the point (2,-1) would place a dot at which point?

A. A
B. B
C. C
D. D
E. E



TYPE THE LETTER OF THE BEST ANSWER AND PRESS ENTER [↵]

Appendix B

Survey of Attitudes Toward Pre-Algebra

This survey will be administered to all Pre-Algebra students at the school before and after the implementation of the practicum.

Appendix B

Survey of Attitudes Toward Pre-Algebra

Name: _____

Directions: This is a survey of what you like best about the Pre-Algebra course. It will not be graded. Please think carefully about each answer and be honest about your feelings. Let's try a practice question:

_____ i. Which do you like better:

A. adding fractions

or:

B. graphing coordinates

Since graphing coordinates is the last chapter of the book, we may not have studied that yet. Graphing coordinates involves drawing graphs with x and y axes on them, then locating points therein. If you enjoy adding fractions better than graphing coordinates, then you should write "A" in the blank provided to the left of the question. If you enjoy or think that you would enjoy graphing coordinates better, then you should write "B" in the blank provided. You may not feel that you like either one very much. Nevertheless, you should write the letter of the one that you like better. Now, let's try some more questions on your own.

_____ 1. Which do you like better:

A. graphing coordinates

or:

B. solving percent problems

_____ 2. Which do you like better:

A. the "Tag Team Algebra" game

or:

B. graphing coordinates

_____ 3. Which do you like better:

A. graphing coordinates

or:

B. learning about the metric system

_____ 4. Which do you like better:

A. solving math puzzles and games

or:

B. graphing coordinates

_____ 5. Which do you like better:

A. solving word problems

or:

B. graphing coordinates

_____ 6. Which do you like better:

A. graphing coordinates

or:

B. multiplying whole numbers

_____ 7. Which do you like better:

A. solving equations

or:

B. graphing coordinates

_____ 8. Which do you like better:

A. graphing coordinates

or:

B. simplifying exponents

_____ 9. Which do you like better:

A. specifying sets

or:

B. graphing coordinates

_____ 10. Which do you like better:

A. doing magic squares

or:

B. graphing coordinates

Appendix C

Comparison of Targeted Students' Pretest and Posttest Scores

Appendix C

Comparison of Targeted Students' Pretest and Posttest Scores

Student #	Pretest Score	Posttest Score	Change
1	35 %	90 %	+ 55 %
2	40 %	80 %	+ 40 %
3	25 %	60 %	+ 35 %
4	25 %	95 %	+ 70 %
5	55 %	100 %	+ 45 %
6	25 %	100 %	+ 75 %
7	50 %	100 %	+ 50 %
8	40 %	100 %	+ 60 %
9	30 %	100 %	+ 70 %
10	50 %	100 %	+ 50 %
11	40 %	40 %	0 %
12	30 %	60 %	+ 30 %
13	50 %	100 %	+ 50 %
14	55 %	100 %	+ 45 %
15	40 %	100 %	+ 60 %
16	55 %	90 %	+ 35 %
arithmetic mean	40.3 %	88.4 %	+48.1 %

Appendix D

Comparison of Other Students'
Pretest and Posttest Scores

Appendix D

Comparison of Other Students' Pretest and Posttest Scores

Student #	Pretest Score	Posttest Score	Change
24	75 %	90 %	+ 15 %
25	70 %	95 %	+ 25 %
26	35 %	85 %	+ 50 %
27	35 %	85 %	+ 50 %
28	40 %	55 %	+ 15 %
29	35 %	95 %	+ 60 %
30	55 %	90 %	+ 35 %
31	65 %	80 %	+ 15 %
32	70 %	95 %	+ 25 %
33	65 %	95 %	+ 30 %
34	65 %	95 %	+ 30 %
35	30 %	45 %	+ 15 %
36	25 %	90 %	+ 65 %
37	35 %	75 %	+ 40 %
38	40 %	95 %	+ 55 %
39	75 %	100 %	+ 25 %
40	65 %	100 %	+ 35 %
41	45 %	100 %	+ 55 %
42	30 %	70 %	+ 40 %
43	65 %	85 %	+ 20 %
44	75 %	100 %	+ 25 %
45	65 %	95 %	+ 30 %
46	55 %	80 %	+ 25 %
47	75 %	100 %	+ 25 %
48	35 %	85 %	+ 50 %
49	75 %	100 %	+ 25 %
50	90 %	95 %	+ 5 %
51	70 %	85 %	+ 15 %
52	20 %	70 %	+ 50 %
53	50 %	100 %	+ 50 %
54	40 %	80 %	+ 40 %
55	45 %	80 %	+ 35 %
56	65 %	75 %	+ 10 %
57	50 %	100 %	+ 50 %
58	50 %	95 %	+ 45 %
59	50 %	95 %	+ 45 %
60	70 %	80 %	+ 10 %

Student #	Pretest Score	Posttest Score	Change
61	40 %	90 %	+ 50 %
62	30 %	95 %	+ 65 %
63	70 %	100 %	+ 30 %
64	25 %	85 %	+ 60 %
65	55 %	85 %	+ 30 %
66	40 %	75 %	+ 35 %
67	65 %	100 %	+ 35 %
68	70 %	80 %	+ 10 %
69	30 %	95 %	+ 65 %
70	25 %	100 %	+ 75 %
71	30 %	80 %	+ 50 %
72	40 %	90 %	+ 50 %
73	85 %	85 %	0 %
74	20 %	70 %	+ 50 %
75	35 %	95 %	+ 60 %
76	55 %	85 %	+ 30 %
77	55 %	95 %	+ 40 %
78	55 %	80 %	+ 25 %
79	30 %	80 %	+ 50 %
80	40 %	90 %	+ 50 %
81	40 %	75 %	+ 35 %
82	50 %	100 %	+ 50 %
83	40 %	95 %	+ 55 %
84	55 %	65 %	+ 10 %
85	45 %	90 %	+ 45 %
86	30 %	95 %	+ 65 %
87	50 %	85 %	+ 35 %
88	60 %	100 %	+ 40 %
89	55 %	70 %	+ 15 %
90	80 %	100 %	+ 20 %
91	40 %	55 %	+ 15 %
92	65 %	95 %	+ 30 %
93	30 %	80 %	+ 50 %
94	45 %	75 %	+ 30 %
95	65 %	75 %	+ 10 %
96	45 %	90 %	+ 45 %
97	50 %	85 %	+ 35 %
98	40 %	80 %	+ 40 %
99	50 %	80 %	+ 30 %
100	85 %	95 %	+ 10 %
101	40 %	65 %	+ 25 %
102	45 %	85 %	+ 40 %
103	65 %	85 %	+ 20 %
104	25 %	75 %	+ 50 %
105	75 %	85 %	+ 10 %

Student #	Pretest Score	Posttest Score	Change
106	20 %	90 %	+ 70 %
107	15 %	80 %	+ 65 %
108	95 %	95 %	0 %
109	85 %	85 %	0 %
arithmetic mean	50.9 %	86.3 %	+35.4 %

Appendix E

Comparison of Targeted Students' Survey Results

Appendix E

Comparison of Targeted Students' Survey Results

Student #	Before*	After*	Change
1	0 %	70 %	+ 70 %
2	40 %	90 %	+ 50 %
3	40 %	100 %	+ 60 %
4	90 %	100 %	+ 10 %
5	40 %	60 %	+ 20 %
6	90 %	100 %	+ 10 %
7	30 %	80 %	+ 50 %
8	10 %	100 %	+ 90 %
9	80 %	90 %	+ 10 %
10	30 %	100 %	+ 70 %
11	30 %	60 %	+ 30 %
12	10 %	70 %	+ 60 %
13	0 %	90 %	+ 90 %
14	10 %	70 %	+ 60 %
15	60 %	50 %	- 10 %
16	40 %	100 %	+ 60 %
arithmetic mean	37.5 %	83.1 %	+ 45.6 %

* responses favoring graphing coordinates as a percentage of total responses

Appendix F

Comparison of Other Students' Survey Results

Appendix F

Comparison of Other Students' Survey Results

Student #	Before*	After*	Change
24	20 %	50 %	+ 30 %
25	30 %	70 %	+ 40 %
26	80 %	100 %	+ 20 %
27	10 %	100 %	+ 90 %
28	10 %	50 %	+ 40 %
29	60 %	90 %	+ 30 %
30	90 %	100 %	+ 10 %
31	70 %	100 %	+ 30 %
32	60 %	100 %	+ 40 %
33	50 %	80 %	+ 30 %
34	30 %	60 %	+ 30 %
35	0 %	100 %	+100 %
36	90 %	100 %	+ 10 %
37	80 %	100 %	+ 20 %
38	70 %	80 %	+ 10 %
39	60 %	70 %	+ 10 %
40	70 %	90 %	+ 20 %
41	60 %	70 %	+ 10 %
42	50 %	50 %	0 %
43	40 %	60 %	+ 20 %
44	100 %	100 %	0 %
45	50 %	80 %	+ 30 %
46	70 %	100 %	+ 30 %
47	40 %	60 %	+ 20 %
48	20 %	80 %	+ 60 %
49	90 %	100 %	+ 10 %
50	10 %	50 %	+ 40 %
51	90 %	100 %	+ 10 %
52	10 %	100 %	+ 90 %
53	50 %	100 %	+ 50 %
54	70 %	80 %	+ 10 %
55	70 %	70 %	0 %
56	40 %	100 %	+ 60 %
57	60 %	90 %	+ 30 %
58	80 %	30 %	- 50 %
59	40 %	50 %	+ 10 %
60	50 %	70 %	+ 20 %
61	40 %	100 %	+ 60 %

Student #	Pretest Score	Posttest Score	Change
62	30 %	60 %	+ 30 %
63	90 %	80 %	- 10 %
64	90 %	100 %	+ 10 %
65	30 %	100 %	+ 70 %
66	50 %	80 %	+ 30 %
67	40 %	90 %	+ 50 %
68	50 %	60 %	+ 10 %
69	10 %	70 %	+ 60 %
70	70 %	90 %	+ 20 %
71	50 %	100 %	+ 50 %
72	0 %	90 %	+ 90 %
73	30 %	90 %	+ 60 %
74	30 %	60 %	+ 30 %
75	60 %	70 %	+ 10 %
76	40 %	60 %	+ 20 %
77	30 %	20 %	- 10 %
78	80 %	90 %	+ 10 %
79	30 %	100 %	+ 70 %
80	40 %	50 %	+ 10 %
81	0 %	60 %	+ 60 %
82	30 %	80 %	+ 50 %
83	20 %	70 %	+ 50 %
84	60 %	40 %	- 20 %
85	10 %	100 %	+ 90 %
86	30 %	50 %	+ 20 %
87	40 %	30 %	- 10 %
88	70 %	100 %	+ 30 %
89	80 %	70 %	- 10 %
90	80 %	80 %	0 %
91	10 %	0 %	- 10 %
92	60 %	0 %	- 60 %
93	20 %	90 %	+ 70 %
94	60 %	40 %	- 20 %
95	60 %	100 %	+ 40 %
96	20 %	90 %	+ 70 %
97	30 %	60 %	+ 30 %
98	50 %	70 %	+ 20 %
99	40 %	30 %	- 10 %
100	80 %	100 %	+ 20 %
101	0 %	100 %	+100 %
102	100 %	50 %	- 50 %
103	70 %	70 %	0 %
104	50 %	30 %	- 20 %
105	100 %	100 %	0 %
106	70 %	70 %	0 %

Student #	Pretest Score	Posttest Score	Change
107	40 %	100 %	+ 60 %
108	100 %	60 %	- 40 %
109	60 %	30 %	- 30 %
arithmetic mean	50.0 %	74.5 %	+24.5 %

* responses favoring graphing coordinates as a percentage of total responses

Appendix G

Documentation

This section includes user documentation, programmer documentation, flowcharts, and a complete program listing.

Appendix G

Documentation

User Documentation

Astrogator is a program that will increase comprehension by math students of plotting points on the Cartesian rectangular coordinate system. The game design of the practice modules will prove highly motivating to students of all ages. The program was written by a secondary mathematics teacher for use by mathematics teachers wishing to expand teaching and learning opportunities.

System Requirements

Compatibility

This program was developed on and is designed for use on any MS-Dos, 8086 or higher system such as an IBM PC or compatible computer. Apple or CPM compatible versions are not available at this time.

Drive Requirements

Only one 3.5 " or 5.25 " disk drive is needed. The user should specify the desired disk size (3.5 " or 5.25 ") when ordering. The program will run faster is loaded on a system using a hard drive.

Color Requirements

Astrogator is available in both color and monochrome versions. Screen one graphics capability is required in either case. The color version is written to take advantage of the color capabilities of a RGB or CGA monitor system. It will, of course, also run on an EGA or VGA system. The monochrome version will automatically run on color of monochrome monitors, but lacks some of the broad range of colors used in the color version. The user should specify which of the two versions is desired when ordering.

Memory Size

Only 128 k of internal memory (RAM) is required to run the program.

Operating Instructions

For the convenience of the user, Astrogator is virtually self-loading. To start the program in a single disk drive machine, simply place the diskette, label side up, in the drive and turn on the computer and the monitor. In a dual disk drive machine, place the diskette in drive A (the bottom drive when the drives are stacked; otherwsie, the left-hand drive). Then turn on the computer and monitor. See Figure 1.

The final step in loading the main Asrtogator program is to type the following information into the computer:

RUN"AG"

Now press the enter key once.

If the system is already booted with MS-Dos and the user does not wish to turn off the computer, it is still possible to load Astrogator. First, return to MS-Dos so that the A prompt appears:

A>

Next, type the command BASIC as follows:

A>BASIC

Press the enter key once and the screen will resemble this:

GW-BASIC 3.20
(c) Copyright Microsoft 1983,1984,1985,1986
Tandy Version 03.20.00
Licensed to Tandy Corporation
61987 Bytes free
Ok

Remove the DOS diskette and place the program diskette into drive A. Type in the command:

RUN"AG"

After pressing the enter key once, the Astrogator program will begin running. If the user desires to run the advanced practice module instead, type the following before pressing the enter key once:

RUN"M"

General Information

The program is user controlled so that it progresses at the student's own rate. **It is very**

important to follow precisely the instructions that appear on the screen. For example, if the computer says to "press enter", press the enter key **once only** after typing the desired response. If the user presses the enter key more than once, the computer may skip a screen or register a wrong answer. Likewise, if the computer says "to continue press any key", then the user should press any key **only once.** If one presses a key more than once in this situation or presses two keys such as a key followed by the enter key, the computer may skip a screen or register a wrong anser. On the menue screen the user also should not press the enter key after typing in the number of the desired module. Please remember to follow carefully the instructions of the computer.

At the start of the program the computer will ask for the user's name. Type in the student's name without any periods and press the enter key once. This will cause the title screen to appear. A special feature for teachers to bypass the title screen and progress directly to the menu is to type the letter Q instead of a name before pressing the enter key once.

The menu screen displays the following five options:

1. Pretest
2. Instruction
3. Practice
4. Posttest
5. Exit the Program

An undisplayed sixth option for the teacher's convenience is accessed by pressing the number six (6). This will give the teacher the choice of viewing the student's pretest scores or posttest scores. After selecting the desired choice, simply type in the student's name when asked to do so and press the enter key once.

Do not press the enter key after typing the number of the desired module.

It is recommended that the user progress through each of the modules in order beginning with the pretest and ending with the posttest. Depending on the individual rate of the student, each module should be completed in approximately 20 minutes. At the end of each module the computer automatically returns to the menu so that the user can progress to any other module or choose to exit the program. The program can be halted at any point by simply pressing the CTRL and Break keys simultaneously.

Both the pretest and posttest modules consist of a series of 20 multiple choice questions and accompanying graphics to measure the students knowledge of plotting coordinates and related information. Five alternatives are given for each question to reduce the possibility of success by guessing. The computer asks the user to select the letter of the one best answer and press the enter key one time. The responses are quietly tabulated by the computer and the final result is displayed on the screen at the end of each test. his screen will show the number of correct answers, the number of wrong answers, and the percentage of correct responses. At the end of the posttest, the screen also displays the pretest score and the difference between the two scores. The results are also saved in files with the student's name for access at any time by the teacher's selecting option six (6) from the menu.

The instruction module covers information needed to understand now to plot coordinates, beginning with a review of the basic number line. Presentation of the underlying concepts proceeds in orderly fashion from that simple idea to the greater complexity of the Cartesian rectangular coordinate system. Immediately following each series of concepts is a brief multiple choice quiz to test the student's learning. Correct responses are reinforced immediately with bright displays and music. Feedback is also given for incorrect responses, but quietly and in a subdued fashion to avoid embarrassment to the student. Nevertheless, the teacher can readily identify students that are having problems by the silence of their machines. Depending upon the severity of the error, the student is either given the nature of his mistake and an opportunity to try another respose, or automatically returned to the tutorial screen to review the pertinent concepts.

The practice module is a highly motivating game utilizing the student's ability to identify the coordinates of a point to destroy 30 threatening meteoroids in a space shuttle's path. The screen automatically registers and displays a cumulative score based on adding 100 points for each correct response and deducting 50 pointsa for each wrong response. Correct response are reinforced by the graphic destruction of the meteoroid accompanied by music. Wrong coordinates result in the meteoroid striking the shuttle. The correct coordinates are also given to help the student learn from his mistakes. To increase

motivation by adding an element of competition, the teacher can establish a time limit for this module (six minutes is recommended) and/or keep track of and reinforce the highest scores. A perfect score is 3000 points.

For more challenge to the student, a separate program is included offering advanced practice. This program is accessed by leaving the main program by pressing the CTRL and BREAK keys simultaneously, then typing RUN"M" and pressing the enter key once. The program that appears is very similar to the practice module of the main Astrogator program, but **the enter key is not used** and an automatic timer is included for each of 30 asteroids. The amount of time allowed before the asteroid hits the shuttle decreases as the program progresses. The time is displayed on the screen and counts down to motivate the student. Since the actual time varies with the type of computer used, the teacher may wish to make sure that all students are on the same type of machine before comparing scores. Scoring is the same as the practice module in the main program except that no points are scored or deducted if time runs out. All answers are reinforced the same as in the main program. A perfect score is 3000 points.

Additional Special Features

In addition to the special features already discussed, the teacher may allow a new student to use the program at any time without having to turn off the computer, re-boot or reload BASIC. Simply press the CTRL and BREAK keys simultaneously, which will stop the program. Then type RUN"AG" or RUN"M" and press the enter key once to access the desired program.

Another feature is consistent color-coding throughout each module of the program. For example, tjhe background of all screens in the pretest module is blue, whereas in the posttest module the background color is black. This enables the teacher to make sure that the student is working on the correct module. Similarly, the background of the instruction module is green and the practice module background is black. For greater contrat, the instruction module background will appear blue if the monochrome version is run on a color monitor.

A final special feature of Astrogator is that the teacher can view the scores of any of the students without having to access the menu. This is done by

typing RUN 14760-then pressing the enter key once.

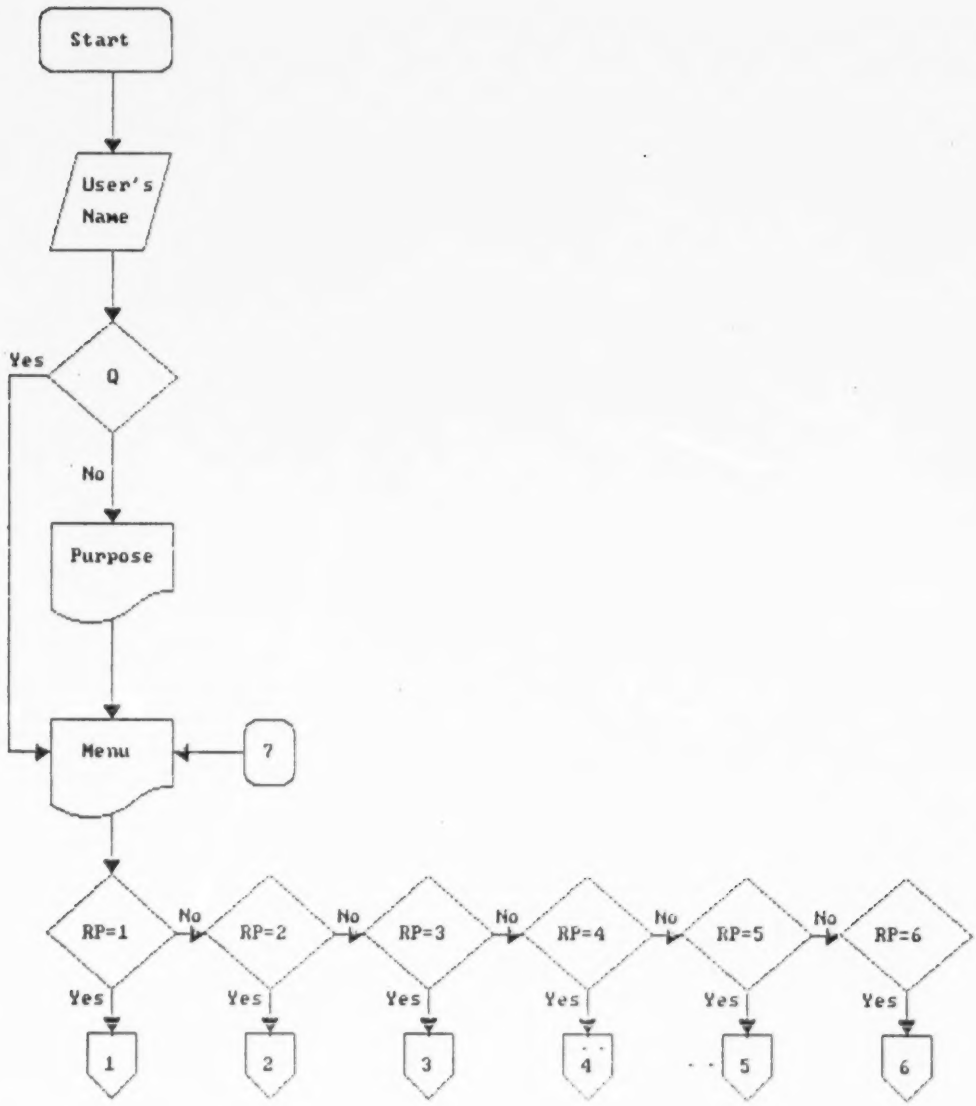
Programmer Documentation

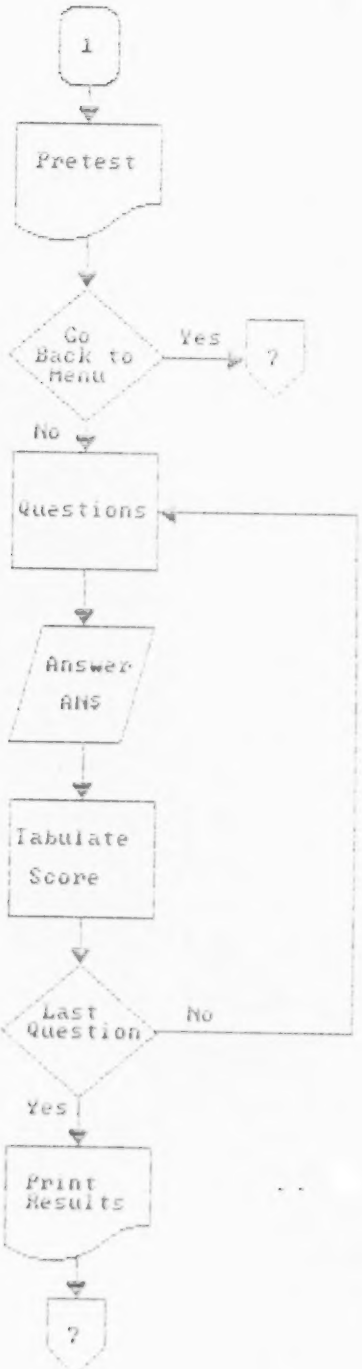
Astrogator is written in GW Basic licensed to Tandy and for ease of loading is called AG.BAS› The program is composed of the following lines and subroutines:

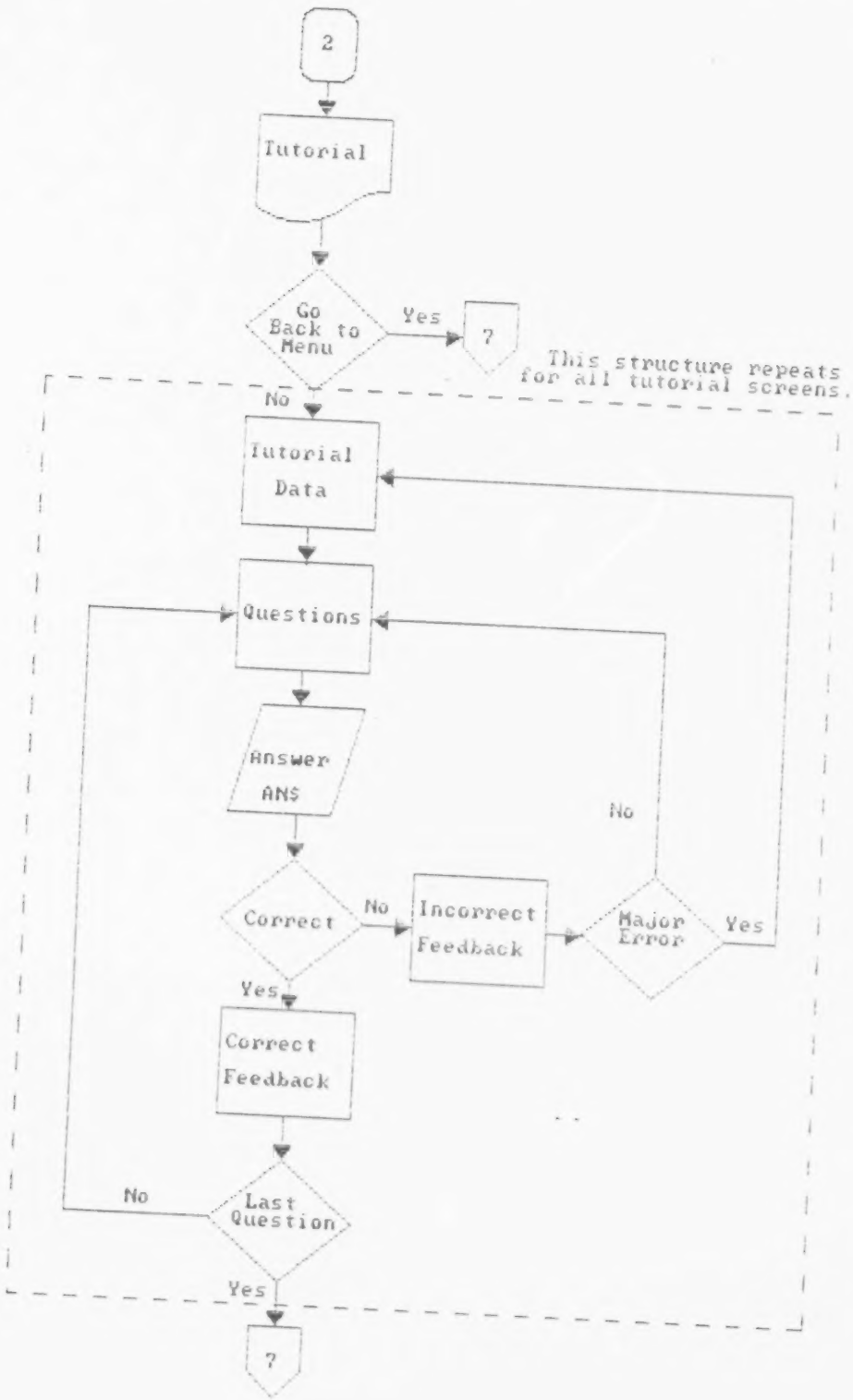
Lines	Description
1000-1530	List of variables
1540-2280	Title screen and credits
2290-2640	Subroutine for title screen graphics
2650-2970	Menu
2980-5580	Pretest
5590-5650	Subroutine for pageturner
5660-5700	Subroutine for right answers
5710-5750	Subroutine for wrong answers
5760-5840	Subroutine for page border
5850-5940	Subroutine for x and y axes
5950-6130	Subroutine for coordinate grid
6140-9230	Instruction module
9240-9320	Subroutine for page border
9330-9410	Subroutine for page turner
9420-9780	Subroutines for correct answers
9790-9840	Subroutine for number line
9850-9910	Subroutine for numbers on coordinate plane
9920-10900	Practice module
10910-11030	Subroutine for screen graphics
11040-11110	Subroutine for input statements
11120-11240	Subroutine for correct answers
11250-11430	Subroutine for wrong answers
11440-11480	Subroutine for x and y labels
11490-11540	Subroutine for numbers on axes
11550-14200	Posttest module
14210-14270	Subroutine for directions
14280-14320	Subroutine for right answers
14330-14370	Subroutine for wrong answers
14380-14460	Subroutine for page border
14470-14560	Subroutine for x and y axes
14570-14750	Subroutine for coordinate grid
14760-14980	Subroutine for student's scores
14990-15070	Closing screen

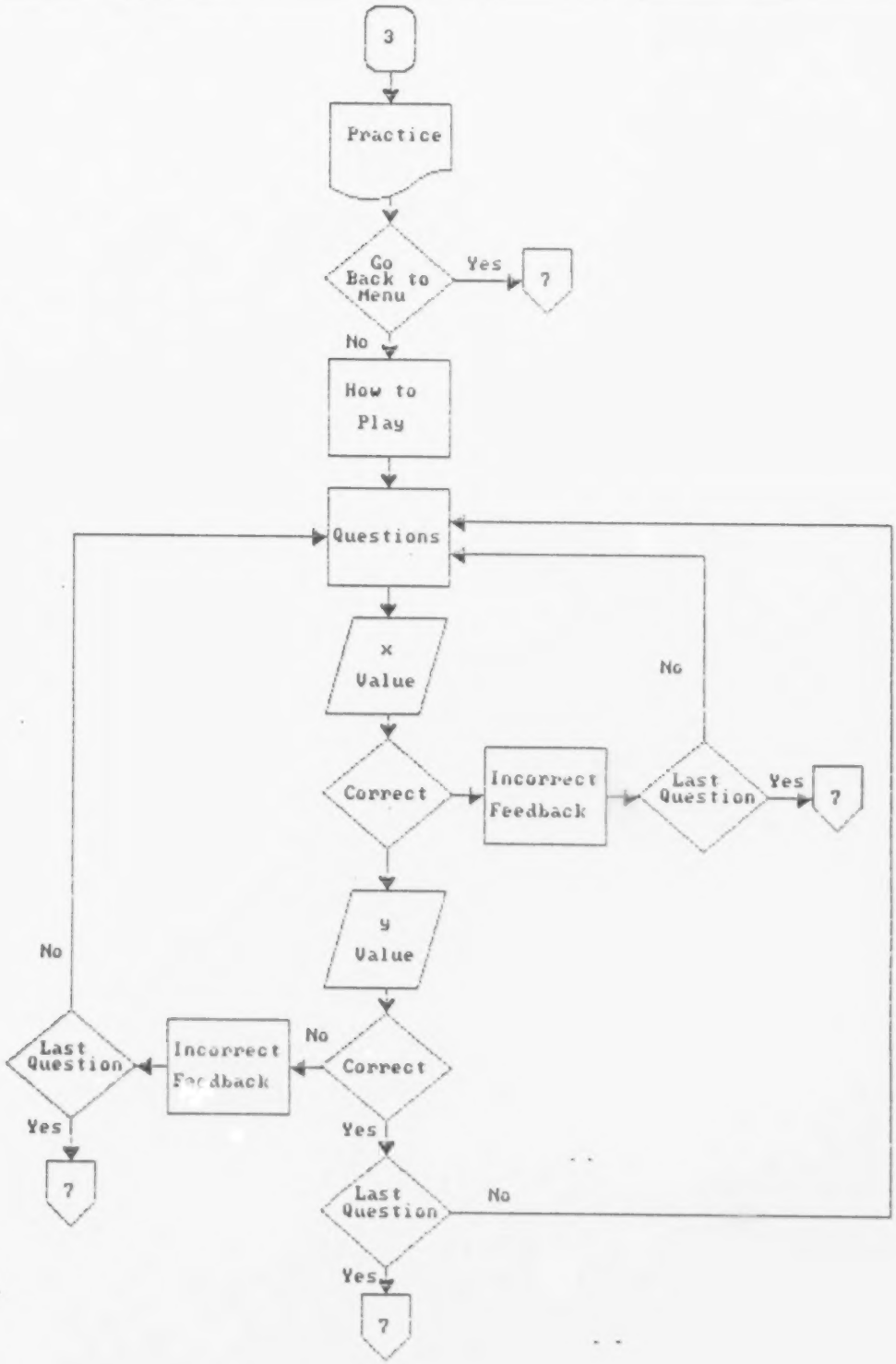
The supplemental program for advanced practice is called M.BAS. This program consists of the following lines and subroutines:

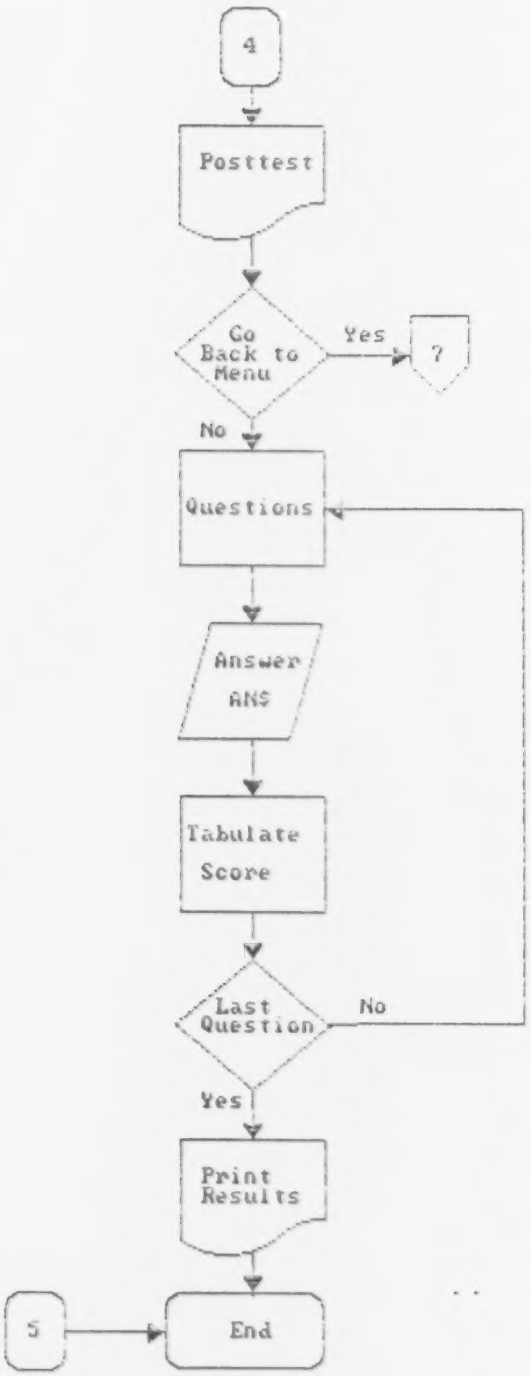
Lines	Description
1000-1290	Variables used
1300-2700	Advanced practice
2710-2860	Subroutine for screen graphics
2870-2980	Subroutine for correct answers
2990-3170	Subroutine for wrong answers
3180-3220	Subroutine for x and y labels
3230-3270	Subroutine for numbers on grid
3280-3420	Subroutine for out of time
3430-3550	Subroutine for x in QI
3560-3680	Subroutine for x in QII
3690-3810	Subroutine for x in QIII
3820-3940	Subroutine for x in QIV
3950-4020	Subroutine for second x character
4030-4110	Subroutine for one y character
4120-4200	Subroutine for two y characters
4210-4280	Subroutine for second y character

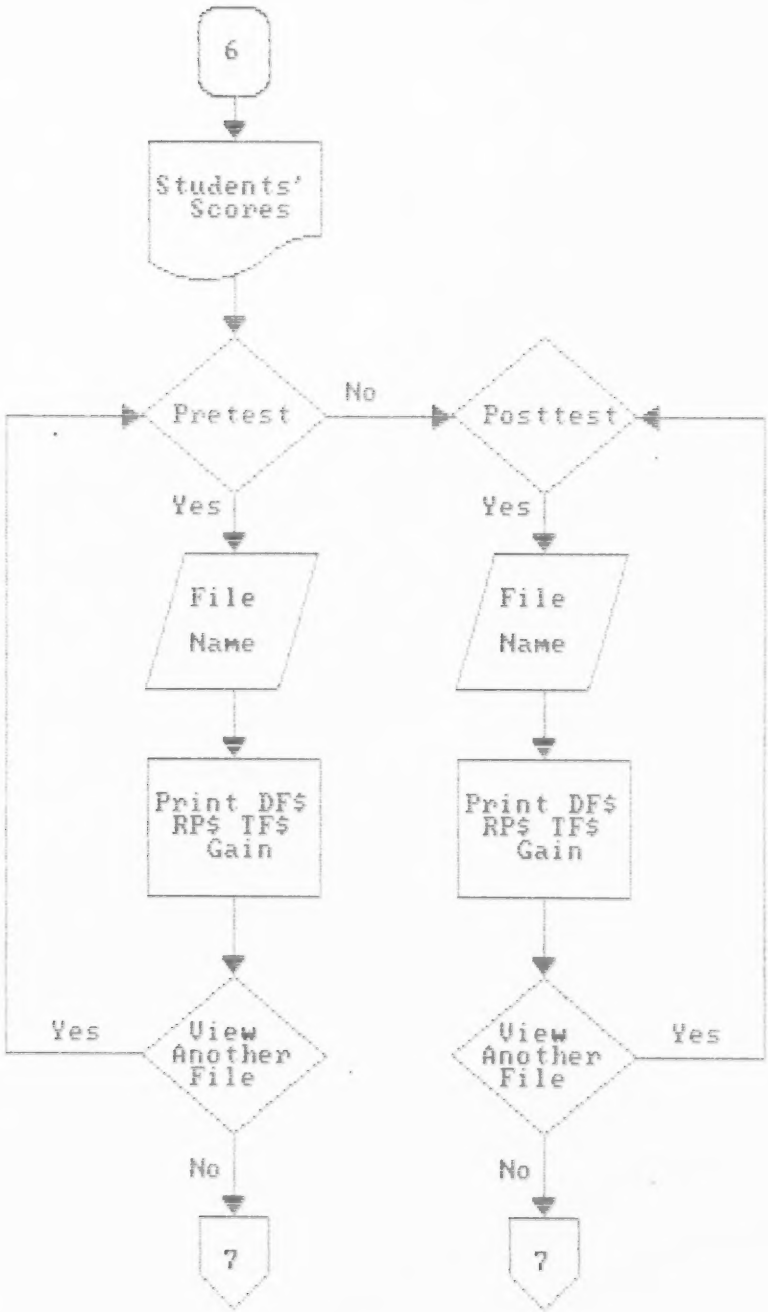

Start
User's Name
Q
Yes
No
Purpose
Menu
7
RP=1
RP=2
RP=3
RP=4
RP=5
RP=6
No
Yes
1
2
3
4
5
6


1
Pretest
Go Back to Menu
Yes
7
No
Questions
Answer ANS
Tabulate Score
Last Question
No
Yes
Print Results
7


2
Tutorial
Go Back to Menu
Yes
7
This structure repeats for all tutorial screens.
No
Tutorial Data
Questions
Answer AN$
No
Correct
No
Incorrect Feedback
Major Error
Yes
Yes
Correct Feedback
No
Last Question
Yes
7


3
Practice
Go Back to Menu
Yes
7
No
How to Play
Questions
x Value
No
Correct
Incorrect Feedback
Last Question
Yes
7
y Value
No
Last Question
Incorrect Feedback
No
Correct
Yes
Yes
7
Last Question
No
Yes
7


4
Posttest
Go Back to Menu
Yes
7
No
Questions
Answer AN$
Tabulate Score
Last Question
No
Yes
Print Results
5
End


6
Students' Scores
Pretest
No
Posttest
Yes
Yes
File Name
File Name
Print DF$ RP$ TF$ Gain
Print DF$ RP$ TF$ Gain
Yes
View Another File
View Another File
Yes
No
No
7
7